Figure 1.1 Telephone networks: (a) network components; (b) digital transmission using modems; (c) multiple services via an H-S modem.

(a) Radio access Analog access circuits Home/small business

Cellular phone network

National PSTNs

Radio access

Digital interconnection circuits

Private site-wide telephone network

Analog access circuit

PSTN = public switched telephone network
GMSC = gateway mobile switching center
IGE = international gateway exchange
LE = local exchange/end office
PBX = private branch exchange

(b) Digital streams Analog access circuits

Digital device Modem PSTN Modem Digital device

(c) Low bit rate telephone channel Analog access circuit

H-S modem

Server

PSTN

High bit rate channel

H-S = high-speed

STB = set-top box

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Figure 1.2 A selection of the network types connected to the Internet.

- Enterprise-wide private network/intranet
- Inter-site backbone network
- Site LAN
- Server computer
- Desktop PC or workstation
- Global Internet backbone network
- Internet service provider (ISP) network
- Site/campus LAN
- Server computer
- Home
- Small business
- Access via the PSTN with modems or the ISDN

LAN = local area network
ISDN = integrated services digital network
G/W = gateway

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Figure 1.3  Broadcast television networks: (a) cable networks; (b) satellite/terrestrial broadcast networks.

STB = set-top box with integral modem
Figure 1.4 Alternative services provided by an ISDN.

- Integrated services digital network (ISDN)
- Single 128kbps switched channel
- Single 64kbps switched channel
- Aggregation electronics
- Digital subscriber line (DSL)
- \( p \times 64\text{kbps} \) switched channel
- Two independent 64kbps channels (basic rate access)
- Single 1.5/2.0 Mbps channel (primary rate access)
- Conventional analog phone

= network termination equipment
Figure 1.5 Example of an ATM broadband multiservice network.

ATM = asynchronous transfer mode  LAN = local area network
MAN = metropolitan area network  IWU = interworking unit
Figure 1.6 Speech-only interpersonal communications: public and private switched telephone networks.

PSTN = Public switched telephone network
PBX = Private branch exchange
ISDN = Integrated services digital network
Figure 1.7 Telephony over the Internet.

G/W = gateway
Figure 1.8 Image-only interpersonal communications: facsimile (fax) examples.
Figure 1.9 Text-only electronic mail: (a) email transfer examples; (b) example email message format.
Figure 1.10 Text-and-image computer-supported cooperative working (CSCW).

- Change notification
- Update control
- Shared whiteboard program

Enterprise-wide private network, LAN or the Internet

Shared whiteboard/workspace
Figure 1.11 Speech-and-video interpersonal communications: (a) two-party video telephone call; (b) videoconferencing using an MCU; (c) videoconferencing using a broadcast network.

(a) PSTN/ISDN/Internet/LAN/enterprise network

Multimedia PC/workstation with video camera, microphone and speakers

Two-way simultaneous integrated speech-and-video information stream

(b) PSTN/ISDN/enterprise network

Multipoint control unit (MCU)

Two-way simultaneous integrated speech-and-video information streams

(c) LAN/Internet

Two-way simultaneous integrated speech-and-video information streams to/from all parties
Figure 1.12 Speech-and-video interpersonal communications: (a) remote lecture; (b) multiparty (group) videoconferencing.

(a) ISDN/broadband network

(b) ISDN/broadband network/dedicated-circuit network

VS = Videoconferencing system
MCU = Multipoint control unit
Figure 1.13 Multimedia electronic mail structure.

Mail header

Hi Tom
If your multimedia mail is working now just click on the following:

- Speech part
- Image part
- Video part

Otherwise the text version is in the attached file.
Regards
Fred

Speech sequence
Image/picture
Video clip

Sent initially
Sent on request
Figure 1.14 Interactions with a World Wide Web server: (a) schematic; (b) hypertext linkages between the pages of a set of documents.

(a) PCs/workstations with browser software

Multimedia information servers (some with transaction capabilities) connected to a site LAN, an intranet, or an ISP network

(b) Navigation toolset

Hyperlinks

Hompage

Navigation toolset

Navigation toolset

Navigation toolset

Navigation toolset

Navigation toolset

= text string containing uniform resource locator (URL)
Figure 1.15 Interactions with a video server: (a) networking schematic; (b) movie-on-demand; (c) near movie-on-demand.

(a) PSTN/cable access network

(b) MOD

(c) N-MOD

MOD = movie-on-demand
N-MOD = near movie-on-demand
Figure 1.16 Interactive television: (a) cable distribution network; (b) satellite/terrestrial broadcast network.
Figure 1.17 A selection of the terms used with multimedia.

Multimedia terminology

Communication modes
- Simplex
  - Symmetric
  - Asymmetric
- Half-duplex
- Duplex
  - Broadcast
  - Multicast

Communication channels
- Synchronous
  - Constant bit rate
  - Circuit-switched network
- Asynchronous
  - Variable bit rate
  - Packet-switched network

Media types
- Continuous
- Variable bit rate
- Block-mode
- Constant bit rate

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Figure 1.18 Communication modes: (a) unicast; (b) broadcast; (c) multicast.

(a) Simplex:

(b) Broadcast:

(c) Multicast: B, D and F are members of the same multicast group
A Circuit-switched network schematic.

Bit rate of the connection determined by the bit rate of the access circuits

Circuit through the network set up using the unique number/address of A and B

A = subscriber terminal/computer

B = switching office/exchange
Figure 1.20  Packet-switching network principles: (a) connection-oriented; (b) connectionless.
Figure 1.21  Multipoint conferencing modes of operation: (a) centralized; (b) decentralized; (c) hybrid.

(a) Conference server

(b) Packet-switched network supporting multicasting (LAN/Internet/Intranet)

(c) Circuit-switched network

= attached terminal/computer
Figure 1.22  Transmission of a constant bit rate stream over a packet-switched network: (a) timing schematic; (b) FIFO buffer operation.

(a)

Constant bit rate input stream

Mean packet transfer delay

Received packet stream

Packetized input stream

(b)

First-in, first-out (FIFO) buffer

Input from network at a variable bit rate

Output at a constant bit rate

Effect of early arrival

Effect of late arrival

Defined level before output starts

\[ T_P = \text{packetization delay} \]

\[ T_N = \text{mean network packet transfer delay} \]

\[ = \text{transmission delay} + \text{mean store-and-forward delay} \]

\[ T_B = \text{buffering delay at destination (to overcome worst-case jitter)} \]

\[ T_T = \text{total input-to-output delay} \]

\[ = T_P + T_N + T_B \]

Jitter = variation in store-and-forward delay about the mean
Summary

Figure 1.23 Alternative types of media used in multimedia applications.

- **Multimedia applications**
  - **Media types**
    - **Text**
      - Unformatted text
      - Formatted text
    - **Images**
      - Computer-generated
digitized documents, pictures
    - **Audio**
      - Speech
      - General audio
    - **Video**
      - Video clips
      - Movies, films
  - Digital form of representation
    - Text and Image compression (Chapter 3)
  - Analog form of representation
    - Audio and video compression (Chapter 4)
  - Integrated multimedia information streams
Figure 1.24 Multimedia communication networks.

- PSTN = public switched telephone network
- PBX = private branch exchange
- ISDN = integrated services digital network
- LANs = local area networks
- ISPNs = internet service provider networks
Figure 1.25 Multimedia communication networks and their services.

- Telephone networks
  - Telephony (fixed and mobile)
  - Voice-mail
  - Facsimile (fax)
  - Access to the Internet
  - Video telephony
  - Speech and videoconferencing
  - Entertainment (video-on-demand, interactive TV)

- The Internet
  - Email and file transfers
  - Multimedia mail
  - Speech and video telephony
  - Videoconferencing
  - Information retrieval and electronic commerce

- Cable networks
  - Analog/digital audio and television
  - CD and video/movie on demand
  - Interactive TV
  - Access to the PSTN
  - Access to the Internet

- Satellite and terrestrial broadcast networks
  - Analog/digital audio and television broadcast
  - Near video/movie on-demand
  - Interactive television

- Narrowband ISDN
  - Digital telephony and fax
  - Video telephony and conferencing
  - LAN interconnection
  - Access to the Internet

- Broadband ISDN
  - ATM LANs
  - ATM MANs
  - ATM backbone networks
  - All interpersonal and interactive applications
  - High-speed network interconnection

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Derive the maximum block size that should be used over a channel which has a mean BER probability of $10^{-4}$ if the probability of a block containing an error – and hence being discarded – is to be $10^{-1}$.

**Answer:**

\[ P_B = 1 - (1 - P)^N \]

Hence \[ 0.1 = 1 - (1 - 10^{-4})^N \] and \( N = 950 \) bits

Alternatively, \( P_B = N \times P \)

Hence \[ 0.1 = N \times 10^{-4} \] and \( N = 1000 \) bits
Determine the propagation delay associated with the following communication channels:

(i) a connection through a private telephone network of 1 km,
(ii) a connection through a PSTN of 200 km,
(iii) a connection over a satellite channel of 50 000 km.

Assume that the velocity of propagation of a signal in the case of (i) and (ii) is $2 \times 10^8 \text{ ms}^{-1}$ and in the case of (iii) $3 \times 10^8 \text{ ms}^{-1}$.

**Answer:**

Propagation delay $T_p = \text{physical separation/velocity of propagation}$

(i) $T_p = \frac{10^3}{2 \times 10^8} = 5 \times 10^{-6} \text{s}$

(ii) $T_p = \frac{200 \times 10^3}{2 \times 10^8} = 10^{-3} \text{s}$

(iii) $T_p = \frac{5 \times 10^7}{3 \times 10^8} = 1.67 \times 10^{-1} \text{s}$
A packet-switched network with a worst-case jitter of 10 ms is to be used for a number of applications each of which involve a constant bit rate information stream. Determine the minimum amount of memory that is required at the destination and a suitable packet size for each of the following input bit rates. It can be assumed that the mean packet transfer rate of the network exceeds the equivalent input bit rate in each case.

(i) 64 kbps
(ii) 256 kbps
(iii) 1.5 Mbps.

Answer:

(i) At 64 kbps, 10 ms = 640 bits
Hence choose a packet size of, say, 800 bits with a FIFO buffer of 1600 bits – 2 packets – and start playout of the bitstream after the first packet has been received.

(ii) At 256 kbps, 10 ms = 2560 bits
Hence choose a packet size of, say, 2800 bits with a FIFO buffer of 4800 bits.

(iii) At 1.5 Mbps, 10 ms = 15000 bits
Hence choose a packet size of, say, 16000 bits with a FIFO buffer of 32000 bits.

Notice that if the computed packet size exceeds the network maximum packet size, then the equivalent number of packets must be sent before playout starts. For example, if the maximum network packet size was 8000 bits, then for case (iii) above playout would not start until two packets have been received and the FIFO buffer should hold four packets.